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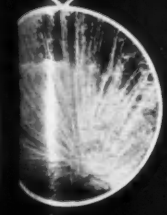

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25¢

What's the Matter - Don't You Trust Me?

Herblock in the Washington Post

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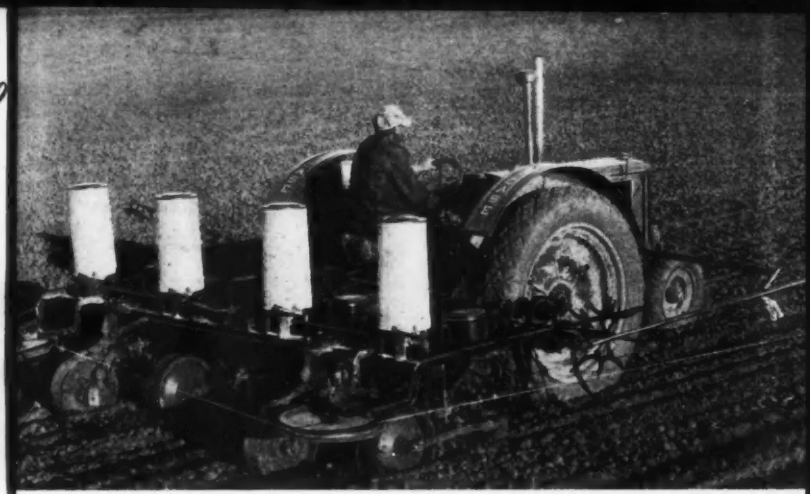

—Photo by courtesy of the Victor Chemical Works.

▶ PHOSPHORUS IN PEACE. *The farmer is spreading phosphate fertilizer on a field in the middle west.*

Phosphorus—Creator and Destroyer

by AUGUSTIN M. PRENTISS,
Brigadier General, Army Service Forces

and WILLIAM H. WAGGAMAN,
Mineral Technologist, Bureau of Mines

▶ AMOS BROWN, a newly hired laborer at one of the larger phosphorus plants had an inquiring mind, and the strange yellow substance oozing through a riveted seam of the electric furnace aroused his curiosity. Picking up a small piece that had dropped into the water trough surrounding the base of the crucible he sought additional information. The specimen promptly burst into flame and the startled investigator hastily dropped it, but not before his calloused palm was painfully burned.

"You . . . so and so," yelled the foreman. "Must I tell you not to touch that stuff!!"

Gazing at his injured hand Amos ruefully replied: "No boss, sumpin already done told me."

There is no doubt that phosphorus is "sumpin" that discourages undue familiarity. Though it engenders no love, it certainly commands respect, and those who know it best handle it with care. When free or uncombined with other elements, this pale yellow wax-like material is a bad actor. It takes fire almost immediately when exposed to the air, burning with a brilliant flame and emitting dense white fumes of phosphorus oxide far more impenetrable than the worst London fog on record. As a smoke

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screen for masking military movements, the fumes of burning phosphorus have few equals. Phosphorus is highly poisonous, even in small doses, and a particle the size of a pin head if taken internally will prove fatal. Constant inhalation of air containing traces of phosphorus vapor was responsible for the so-called "phossy jaw" or rotting away of the jaw bone, a disease that was quite common among workers in match factories until the use of yellow phosphorus in matches was prohibited by law.

Yet this distinctly unpleasant substance, when combined with or wedded to other elements, loses its evil character, yielding benign products that are essential to life and highly important to the many peacetime industries that promote the advance of civilization.

After Amos Brown's painful introduction to elemental phosphorus, it would have been rather difficult to convince him that his blood, bones, and brain contain this evil element, that the flour in the biscuit he consumed at lunchtime was derived from gain grown by the aid of phosphorus fertilizers, that the dough had been leavened with phosphate baking powder, that the washing powder he used to clean up after his day's labor was a phosphorus salt and that the less worn parts of the dilapidated jalopy in which he rode home had been rust-proofed by a solution of a phosphorus compound. After Amos had grasped these perplexing facts, he no doubt would have reverently agreed that phosphorus really is "sumpin."

A multitude of civilian jobs await phosphorus, now that it has been released from its military duties, but for nearly four years it effectively fought our savage and ruthless enemies. The inflammability of phosphorus and the nature of the fumes evolved when this element is burned were partly responsible for forcing the unconditional surrender of Germany and her misguided satellites, and unquestionably hastened the collapse of Hirohito's empire.

Phosphorus in the War

During the early years of the war, the Royal Air Forces scattered millions of thin disks of damp guncotton impregnated with phosphorus over agricultural areas in Germany with a view of destroying fields of ripening crops. These so-called "visiting cards" soon dried sufficiently for the phosphorus to take fire, igniting the guncotton which burned with an intensely hot flame that spread rapidly to any nearby combustible material. Undoubtedly these little tokens did considerable damage, but they were merely the forerunners of the grenades, shells and gigantic phosphorus bombs that later were used so liberally.

Compared with other incendiaries, phosphorus has certain advantages and disadvantages. It sets fire to readily combustible materials, but does not develop the intense heat that enables thermite and certain other magnesium and aluminum mixtures to burn their way through metal and destroy less flammable targets. Unlike oil and gasoline, it is easily extinguished by water, but re-ignites as soon as the water drains off; therefore, until the phosphorus is com-

—Photo by courtesy of Monsanto Chemical Co.

▶ PHOSPHATE ROCK *is quarried and sent to a refining plant to be made into fertilizer or converted into special forms for other uses.*

pletely removed or neutralized, it continues to be a fire menace.

The highly flammable nature of many Japanese buildings was responsible in part for the immense damage caused by our bombing raids on Tokio and other industrial cities. The Japs found it pretty discouraging, after extinguishing a fire, to have it rekindled when the fire brigade had left.

The effect of phosphorus on our enemy's fighting forces was equally demoralizing. Phosphorus grenades and shells scatter flaming, sticky particles that cannot be dodged. Foxholes and caves were filled with showers of searing flame, and the damage was done before water could be applied even if ample quantities were at hand. No matter how fanatical a Jap might be, he did not fancy joining his ancestors via the phosphorus route.

While phosphorus incendiaries were destroying the enemy and his power for waging war, it was also being used to protect our own forces against attack.

Phosphorus shells carefully lobbed over the heads of advancing or retreating forces created a dense white

smoke-screen, effectively masking the movement of troops and rendering it impracticable for the enemy to locate the target. During some of the fierce struggles for possession of certain strategic islands in the Pacific, when the Japs were exacting a terrific toll for every yard gained by our troops, phosphorus shells were dropped just ahead of the enemy's position, enabling the stretcher bearers to rush out and bring our wounded back to the American lines. Thus, as the greatest war of all times went into its final stages, American-made phosphorus played an increasingly important role in our ultimate victory.

If phosphorus is such an effective war weapon, however, why was it not employed by the Nazis and also, why did not the Japs give us a dose of our own medicine? As a matter of fact, both the Germans and Japanese did use phosphorus as long as they could obtain the raw material required for its manufacture, but as the United Nations gained the initiative, practically all such material fell into their hands, and though we gave the enemy plenty of phosphorus, it was in a form that literally "burnt them up."

The main source of phosphorus is phosphate rock, or phosphate of lime, a mineral widely distributed in nature but occurring in commercial quantities in relatively few areas. The United States is fortunate in possessing the world's largest phosphate reserves and has far greater facilities than any other nation for converting this rock into elemental phosphorus. These deposits in Florida, South Carolina, Tennessee, Utah, Idaho, Wyoming and Montana—are so vast that, at any predictable rate of consumption, they will last us well over one thousand years. The other important phosphate deposits occur in North Africa, Russia, and in certain small islands in the Pacific and Indian Oceans.

Neither Japan nor Germany proper has appreciable quantities of phosphate rock, and these countries need it badly for fertilizers to maintain the intensive agricultural system necessary to feed their people. Before the war, those nations were our best foreign customers for this commodity and it is suspected that in the early days of the world conflict, phosphorus made from American rock was used against our own armed forces.

After the collapse of France, Germany fell heir to the highly developed phosphate deposits in Algeria, Tunis and Morocco and shipped large tonnages to the homeland for agricultural, chemical and war purposes. When General Montgomery stopped Rommel on the Egyptian border, and later, in conjunction with the American forces, threw the Nazis and their Italian allies out of Africa, Germany's supply of phosphate rock was completely cut off. What stocks she had been able to accumulate were needed for fertilizer purposes to bolster up her phosphorus-deficient soils and she could no longer afford to manufacture and use phosphorus as a war weapon. Likewise when Japan gained control of the western Pacific, she took over the exceptionally rich phosphate islands (formerly controlled by the British) and exploited them as rapidly as possible for her own benefit. When, however, the American offen-

sive got under way, and Japanese shipping began to disappear from the seas, these sources of phosphorus were lost, and it was impracticable for her to manufacture elemental phosphorus from her fast dwindling stockpiles.

How long the Japs would have been able to maintain their agricultural production without the aid of phosphatic fertilizers is problematical, but sooner or later their yield of crops was bound to fall and their already restricted diet must have been curtailed even further. Fortunately for all concerned, the atomic bomb and Russia's entry into the war persuaded them to call it quits before they felt the pangs of hunger.

America's Unique Position

Unlike Great Britain, France, Germany, Italy, Japan, and many other nations, the United States is independent of outside sources for its phosphorus supplies. Hence, no blockade or disruption of shipping facilities can cut off these materials. Yet in spite of the fact that American phosphate resources were considered to be large, alarming reports have been circulated from time to time that we were draining them for the benefit of European agriculture. Bleak

▶ PHOSPHATE ROCK *is converted into superphosphate by action of sulfuric acid if it is to be used for fertilizer, or smelted and distilled to yield elemental phosphorus.*

—Photo by courtesy of Monsanto Chemical Co.

—Photo by courtesy of International Minerals & Chemical Corp., Mulberry, Fla.

➤ FLOTATION PROCESS, *new in phosphate works, are increasing our resources by making it practical to use lower grade deposits and rework old sites.*

pictures were painted of what was in store for us if we continued to export phosphate rock to other countries while our own soils gradually wore out for lack of phosphorus fertilizers.

These disturbing reports were brought to the attention of President Roosevelt in 1938 and in order to ascertain the facts, he appointed a joint Congressional Committee to investigate our phosphate reserves and determine if there was need to curtail or prohibit exportation of this mineral.

The investigation was thorough and many outstanding scientists and economists were called upon to testify. Government representatives included geologists, engineers and chemists from the Geological Survey, Bureau of Mines, and Department of Agriculture. The phosphate industry heartily supported the investigation and not only made production records available to the Committee, but furnished detailed prospecting data that previously had been jealously guarded.

The Committee concluded that the domestic reserves of phosphate rock are ample for many generations and the final figures showed estimated resources of over thirteen billion tons or sufficient for over 2,500 years at our present rate of consumption. Thus, the bugaboo of a phosphorus shortage has been definitely dispelled.

Only recently the Bureau of Mines has found that certain low-grade phosphates in the West contain appreciable quantities of vanadium, an element of great importance in the manufacture of alloy steel. Methods

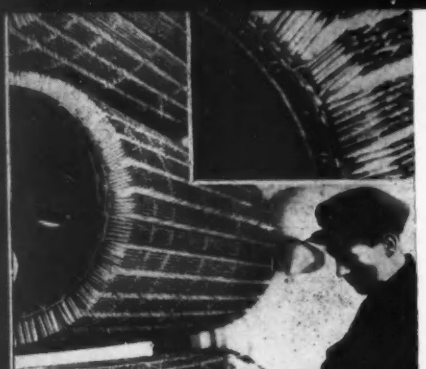
—*Photo by courtesy of the Victor Chemical Works.*

➤ TRICALCIUM PHOSPHATE *makes salt run freely even on those muggy days in midsummer.*

of extracting such vanadium are being investigated by the Bureau, as it promises to constitute a valuable by-product and render this country less dependent on outside sources for this relatively scarce metal.

In Alabama, Tennessee and Florida, electric furnaces consuming enough current to furnish light and power for several large cities are running night and day turning out phosphorus at a rate undreamed of a relatively few years ago. The combined capacity of these plants is approximately 85,000 tons of phosphorus a year, a sharp contrast to our phosphorus-producing capacity of less than 10,000 tons annually during the world war of 1914-18.

In manufacturing phosphorus from phosphate rock this mineral is mixed with sand and coke and smelted in an electric furnace at approximately 3000° Fahrenheit. The rock thus reduced yields a molten slag, and elemental phosphorus is distilled off and condensed by water to a heavy liquid. Phosphorus may be stored indefinitely as long as it does not come in contact with air. It can be molded into



—Photo by courtesy of the Victor Chemical Works.

➤ THOSE SWEDISH MATCHES *come from factories like this. Phosphorus is the element that consigned flint-and-steel and the tinder-box to the museum.*

cakes and packed in drums or in liquid form, it may be pumped through steam-heated pipelines into tank cars. A phosphorus-filled tank car is literally "hell on wheels," but as long as it is kept closed, the sinister contents are under control and can be transported with little risk.

Plowshare and Sword

Phosphorus is not only a powerful and effective weapon of offense and defense, but it is the cornerstone of our agricultural wealth and an essential constituent of many products that make for a more abundant life. Under normal conditions relatively little phosphorus is used in the elemental state, and although a large tonnage is produced annually, the phosphorus itself may be considered an intermediate product employed in the manufacture of phosphorus compounds. Small amounts of the element are employed in rat poison, in producing special alloys, and in manufacturing red phosphorus which is neither poisonous nor spontaneously combustible. Red phosphorus is contained in the striking surface of the safety match box and in the little brown strip of the match book which we use so freely. Although Americans strike fully 500,000 such matches every minute of the day, the actual phosphorus thus consumed represents but a few thousand tons per year.

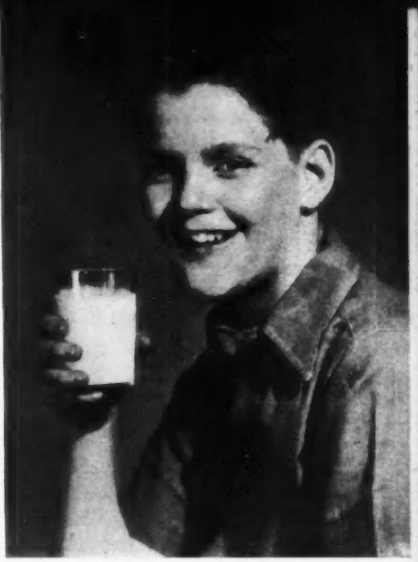
Most of the elemental phosphorus produced is burned or oxidized yielding white fumes of phosphorus oxide which can be condensed to a solid, or treated with water to form a highly corrosive syrupy liquid known as phosphoric acid. This acid played an important role prior to the war, but new developments have greatly expanded its field of usefulness. It is used in dilute form to impart tartness and palatibility to soft drinks, and is also an ingredient of tonics and medicinal preparations; as concentrated acid it is a powerful and useful chemical reagent. By treating various alkalis and alkaline earths with phosphoric acid, phosphate salts are formed which have wide industrial applications. Phosphoric acid partially neutralized with lime, yields a compound known as monocalcium phosphate which is one of the active ingredients of many popular brands of baking

powders and self-rising flours. Other phosphates of lime are used in stock feeds and in conditioning table salt to prevent caking during damp weather. Phosphates of soda are employed in the weighting of silk, in the dyeing industry and in a large number of washing powders and water softeners. Recently a phosphate glass has been developed that is not attacked by hydrofluoric acid, a chemical the fumes of which heretofore have rendered the window panes in certain factories almost opaque.

Solutions of phosphoric acid containing iron and manganese are employed in the rust-proofing of steel and other metals, and certain organic phosphates enter into the manufacture of plastics that offer much commercial promise in the postwar period.

Service—Night and Day

From dawn till dusk, and even while we sleep, compounds of phosphorus are serving us continuously. When we brush our teeth on arising, phosphate of lime is often the abrasive ingredient in the toothpaste we use; whether we array ourselves in cotton, wool or silk, phosphorus has been instrumental in the production of the original raw material; the orange juice and cereal with which we begin breakfast are derived from fruit and grain grown by the aid of phosphate fertilizers; the waffles and hot biscuits owe their lightness to phosphate baking powder, and even yeast is propagated by cultures containing phosphate salts. Phosphate in the form of bone black or phosphoric acid paste is employed in purifying



—*Photo by courtesy of the Victor Chemical Works.*

▶ PLENTY OF PHOSPHORUS *in the diet of this husky youngster.*

the sugar that sweetens our coffee, and the "free running" properties of the salt with which we sprinkle our eggs is due to the addition of small quantities of lime phosphate.

That tender, juicy pre-war steak which is still largely a memory came from a steer that had been fed a nicely balanced diet containing phosphorus compounds.

With the exception of water, every beverage, whether it merely soothes and refreshes, or provides a more potent stimulus, is produced by the aid of phosphorus derivatives.

As we relax in an easy chair, strike a light on a phosphorus coated matchbox and seek solace in a quiet smoke, we are indebted to phosphorus for its

role in producing the fragrant tobaccos for our favorite cigar or cigarette.

Whether our nightly ablutions are more or less perfunctory or we indulge in the luxury of a glamorous bubble bath, the addition of a small quantity of certain phosphate salts imparts that softness to the water so necessary to obtain its full cleansing effect.

Finally, as we sink into slumber after a day of postwar growing pains we should breathe a prayer of thanksgiving for our Nation's vast phosphorus resources that not only helped provide the cotton sheets between which we lie, and the blanket that keeps us comfortable throughout the night, but which also effectively backed up our stalwart sons in their fight to maintain the American way of life.

Although phosphorus itself is highly combustible, compounds of phosphoric acid and ammonia are widely used for flame-proofing purposes. Draperies and theatre curtains, treated with a solution of ammonium phosphate and borax, greatly reduce fire hazards.

The bulk of phosphorus consumed in this country, however, is in the form of phosphate fertilizer and under present conditions when the crop-producing power of our soils is being taxed to capacity, greater quantities of phosphate rock are being employed for this purpose than ever before in the nation's history. Over five million tons of this mineral were used in 1944 and even larger amounts were consumed in 1945.

In manufacturing fertilizers from phosphate rock, it is not necessary to reduce the mineral to elemental phosphorus. The standard method of producing them consists in finely grinding the phosphate rock and then mixing it with almost an equal quantity of strong sulphuric acid. A rather violent reaction thus takes place between the acid and the rock and the resultant product is a porous, relatively dry, solid mass. This product which is known as superphosphate is subsequently broken up, screened and marketed. It is the backbone of the fertilizer industry and the basis of nearly all so-called "complete goods." Approximately 85% of the rock mined last year was thus treated in the numerous fertilizer factories strategically located for the distribution of superphosphate to important agricultural areas.

On the Back Cover

▶ PHOSPHORUS IN WAR. *A shell loaded with the deadly element explodes behind the target silhouetted against its glare. Photograph by courtesy of U. S. War Department.*

Role of Phosphorus Wins Prize For Synthesis of Complex Sugars

Two New Sugars Invented

▶ FOR FINDING the key to the sugar molecule, which enabled them to build up synthetic cane sugar for the first time from simpler compounds, Drs. W. Z. Hassid, M. Doudoroff and H. A. Barker, research workers at the University of California, have been awarded the first intermediate $5,000 Sugar Research Foundation prize from the National Science Fund of the National Academy of Sciences.

Two sugars never found in nature have been invented by these scientists.

Cane sugar is a double molecule, built up of two simpler sugar molecules. Many earlier attempts to link up the simpler sugars have failed because the role of phosphate compounds in building up the more complex molecule was not appreciated.

The California scientists succeeded, with the aid of an enzyme obtained from a culture of the bacterium Pseudomonas saccharophila, in combining glucose phosphate with fruit sugar to make the same sugar we get from sugar cane or sugar beets. The phosphorus compound pulls the two simple sugars together, then steps out of the picture. Until the experiments of Dr. Hassid and his colleagues, the part played by the phosphate group was not known to be essential.

Having found the key to the problem, the research group has since used this new method to make two other sugars unknown in nature and never seen or tasted by man before.

Three kinds of double sugars, in addition to cane sugar, are known in nature. One of these is lactose, or milk sugar. Another is maltose, formed in sprouting grain, which feeds beer yeasts and contributes to the flavor of malted milk. The third is cellobiose, formed by chemical treatment of wood. These three kinds of sugar are made up of pairs of similar molecules.

One of the new synthetic sugars made by the California scientists follows essentially the same pattern. Glucose phosphate was made to combine with sorbose to make glucosido-sorboside, an unknown product, instead of glucosido-fructoside, the material for which your grocer collects ration stamps.

But sorbose, the unusual constituent of the new sugar, is not very different from glucose. Similar arrangements of the same atoms make up its molecule. The two differ only in whether certain groupings of atoms occur on the right side or the left side of the molecular structure. Such differences make some alterations in how fast sugars dissolve and how sweet they taste, but chemically sorbose and glucose are two of the possible 16 sugars of the same pattern. Linking these sugars results in double sugars of the maltose, lactose, cellobiose type.

The second new sugar formed by Dr. Hassid and his co-workers is built more on the pattern of cane sugar. The simple sugar which is joined to the glucose phosphate is ketoxylose.

The structure of ketoxylose is similar to that of the fructose half of the cane sugar molecule. Both are ketoses, whose structure is fundamentally different from that of glucose, although both contain equal numbers of the same carbon, hydrogen and oxygen atoms.

Now that the simple sugars, which can be put together chemically, have been synthesized to double sugars by the new process, the research group hopes to be able to use the new "tagged atom" technique, made available by atomic research, to learn what use is made by the body of the two halves of the sugar molecule.

Each half could be studied separately as it undergoes transformation to blood sugar, which plays such an important part in nutrition and body chemistry. The newly appreciated importance of phosphorus compounds in sugar synthesis can also be followed by the introduction of compounds of the radioactive phosphorus isotope into the reactions discovered by Drs. Hassid, Doudoroff and Barker.

The synthesis of sucrose or of the new sugars will find no use in increasing the food supply. These researches will not lessen the sugar shortage.

New compounds of the many sugar-like substances already known, and perhaps others, to be formed by modifications of known processes, will bring to research workers many opportunities to learn how the growing plant builds up the carbohydrates upon which we in common with all animal life depend for food.

Fibrous Glass for Life Belts

➤ FIBERGLAS mats, developed originally for use in storage batteries, are now found to be valuable in several other applications. They are employed with success for wrapping underground oil, gas, and other pipe lines to protect them against electrolytic action and corrosion; as a base for a new plastic laminated material; and as a base material for gaskets and sheet packing. These mats are made here by the Owens-Corning Fiberglas Corporation.

Glass fibers are non-corrosive to metals and have negligible moisture pickup. The mats of this material can be wrapped around bitumen or coal tar-coated pipe, thus forming a continuous water-tight bond. The tensile strength of the material withstands a wide range of temperatures, and exposure to organic solvents and soil acids.

The new plastic laminated material in which fiberglas is used, has many electrical uses because it possesses a low and stable loss factor over a wide wave frequency range. It is employed in plastic coil forms, condenser spacers, stand-off insulators, and in radio, television and other high-frequency electronic devices.

In the base material for gaskets and sheet packing, the mat acts as a carrying medium for synthetic resins suitable for applications requiring resistance to heat, oil and acids. The gaskets show high pressure resistance, good chemical durability and little flow under flange pressure.

Chem Quiz

What For?

➤ SOME METALS are used for such specific things that the mention of the use calls the metal at once to mind, as spoons make you think of silver. For the following list of uses, what metals do you think of? Why not turn to page 32 to check your list?

electric connections
flashlight powder
cancer treatment
fireworks
thermometers
galvanizing iron
fountain pen points
cigarette lighters
photoelectric cells
neutrons
atomic bombs
bright finishes
money standard
plated food containers
storage batteries
making poisons

Slab Zinc Production

➤ SLAB ZINC production in the United States during 1945 totaled nearly 800,000 tons, which is higher than prewar production but considerably less than the output during war years, the American Zinc Institute has announced. Galvanizing resumed its place as the principal outlet for zinc, while there was a sharp reduction in the total tonnage of the metal used in making brass, thanks to the silencing of the guns.

Consumption figures compiled by the institute begin to show the transfer from war to peacetime uses in 1945. Galvanizing, the prewar leader in zinc consumption, fell to second place in 1942, with brass products jumping far ahead. In 1943 more than 419,000 tons of slab zinc went into brass products, while in 1945 only about 261,000 were thus used.

Zinc used in zinc-base alloys is getting back to the higher levels of earlier years, the institute states. The amount used in rolled zinc in 1945 is practically double the 1943 figure.

The bulk of zinc consumed in paint and other pigments, according to the secretary of the Institute, is derived directly from ore. In the last four years from 110,000 to 115,000 tons of zinc per year from primary sources have entered the production of zinc and lithopone.

American mines produced in 1945 zinc ore containing a little more than 608,000 tons of recoverable zinc. Zinc ore imports, measured in zinc content, were nearly 354,000 tons. In addition, 87,500 tons of slab zinc were imported, practically all from Australia, Canada, and Mexico.

Story of the Anti-Diabetic Hormone Told by One of Its Discoverers

The Development of Insulin

by SURGEON CAPTAIN C. H. BEST R. C. N.

Director, Banting and Best Department of Medical Research and Department of Physiology, University of Toronto.

In his Banting Memorial Lecture for 1945, Capt. Best, who, twenty-five years ago, worked with the late Sir Frederick Banting on the isolation of insulin, tells some of the outstanding experiences remembered about that pioneer research. The following extract from Capt. Best's lecture is reprinted with permission from the Canadian Medical Association Journal, Montreal.

I WOULD LIKE this afternoon to outline very briefly the improvement in the insulin preparations from the first crude ones which we had available in 1921 to the pure products of today. The impurities present in the first extracts may have delayed the liberation of the insulin even when administered intravenously but this was much more apparent when similar material was given subcutaneously. The first extracts from normal beef pancreas, prepared with the modifications and improvements made by Professor Collip in the procedure which we originally used, had an appreciably longer duration of action than an equivalent amount of the purer insulin now available. I do not wish to imply that the early extracts were not effective in the treatment of depancreatized dogs or of diabetic people. They were amazingly good and a part of their effectiveness, when administered subcutaneously, was undoubtedly due to the gradual and therefore prolonged period of absorption of the potent material.

The natural goal of the chemist is to prepare substances in their purest form and insulin soon attracted the attention of a very competent group under the leadership of the late Professor J. J. Abel who obtained insulin in crystalline form in 1926. A little later my colleague of long standing, Dr. D. A. Scott, showed that these crystals are the zinc salt of the insulin protein. These zinc insulin crystals are made up of twin plaques which can be clearly seen as the crystals rotate. Crystalline insulin has been prepared not only with zinc but Scott and Fisher have successfully used other materials such as piperidine, normal amylamine and isoamylamine.

The first international standard of insulin adopted by the Health Organization of the League of Nations (which has brought order out of chaos in the whole field of biological standardization) was non-crystalline and had a potency of 8 units per mgm. The present standard—the material for which was made in the Connaught Laboratories of our University—is composed of the zinc insulin crystals and has a potency of 22 units per mgm. The creation of these international yardsticks has been largely responsible for the uniform

potency of insulin the world over and the accurately predictable effect it has exerted on the uncomplicated case of diabetes.

Crystalline insulin is made up entirely, as far as can be ascertained, of protein, and contains the following amino acids: serine, theonine, glutamic acid, cystine, leucine, lysine, arginine, histidine, phenylalanine, tyrosine and proline. The number and complexity of these building stones make the possibility of synthesis of insulin remote. These amino acids are presumably joined together in one special manner by nature to form the insulin molecule. There are many thousands of ways in which the building stones might be united.

From the practical viewpoint, *i.e.*, of the treatment of diabetes, the successful purification of insulin was not an unmixed blessing. Solutions made with the crystals had a shorter duration of action than many of the less pure preparations. Having completed the task of purifying insulin it was necessary to replace the impurities by a harmless and inert substance which would delay the absorption of the active material, *i.e.*, to add a pure "impurity" which would form a compound with insulin from which the latter would slowly be liberated. Many attempts were made to accomplish this objective but the first practical solution came from Hagedorn and his group in Copenhagen who developed protamine insulin. Protamine insulin was a most valuable, but relatively unstable material and it was greatly improved when Drs. D. A. Scott and Albert Fisher of the Connaught Laboratories added a small amount of zinc. More than half the insulin now used in Canada or in the United States is protamine zinc insulin. Many attempts to improve this product have been made. Clear solutions of relatively slow-acting insulin, such as globin insulin, have been prepared. Clinical opinion, however, is still largely in favour of protamine zinc insulin but slight changes such as an increase in the insulin to protamine ratio may be introduced.

The Supply of Insulin

When our only source of insulin was from dog's pancreas the ducts of which had been tied some 8 or 10 weeks previously, Banting and I visualized herds of cattle upon which this operation had been performed at the appropriate interval before their demise. Indeed we went as far as obtaining some steers at the country seat of the Connaught Laboratories and after anaesthetizing them we rearranged their internal structure to suit our convenience. Happily, from all viewpoints, this procedure on a large scale was not required and after passing through a phase when fetal calves were at a premium, we found that commercial beef pancreas extracted with alcohol, provided us with a readily available source of the internal secretion. Now, the pancreas from one steer may weigh approximately one-half a pound and will provide enough insulin to treat the average diabetic patient for about two weeks. Obviously, therefore, the number of cattle available in the world acquires an additional interest in the minds of many millions of people.

The discovery of a readily available source of insulin in 1921 did not im-

mediately remove all the obstacles to a more satisfactory rate of production. The advances in methods of purification which Professor Collip made were of great importance but knowledge of the properties of insulin was so meagre that, even after treatment of patients had commenced, the secret of securing active material was lost for weeks—which seemed years! The struggle in the sub-basement of the Medical Building during the winter and spring of 1922, deserves a chapter for itself. The wind tunnel in which acetone extracts of pancreas were evaporated with the help of hot (and unprotected) electric wires, the gigantic flask which exploded, the first metal still whose hungry condenser demanded and received two tons of ice per day (delivered by hand), the floods, and the wild rats, all these made lasting impressions on me and on my first scientific colleague, D. A. Scott, in what was then called the Insulin Division of the Connaught Laboratories. Production gradually improved. The insulin supplied at this time contained only from five to ten of the present units per cubic centimeter in contrast with the 40, 80 or 100 unit material now available.

The primitive insulin plant in the Medical Building was followed by a much more efficient one constructed in the house which had previously accomodated the University Young Men's Christian Association. Many of you do not remember this little structure which stood in the shade of some fine elms somewhere between the present School of Hygiene and the Engineering Building. This unit continued to serve a most useful purpose until the insulin plant was transferred to the School of Hygiene in 1927.

If one had been asked to predict the curve of insulin distribution from 1922 to 1945, many of us would have suggested a very steep rise during the first five or six years and a much more gradual increase from there on. This has not been the case, and the total distribution of insulin in Canada and the United States has doubled every five years for the past fifteen years. While a small proportion of the insulin used has been for non-diabetic, particularly mental, cases, the main demand has been for the treatment of the rapidly increasing number of diabetics. The dramatic lowering of the mortality rate of young diabetics and increase of the life span of diabetics in all age groups has been recently summarized by the Metropolitan Life Insurance Company.

"Today, the average diabetic child of ten may be expected to celebrate his fiftieth birthday, whereas just prior to 1922 most diabetic children lived little more than one year after the onset of their disease. At age thirty expectation of life is now twenty-seven and one-half years, compared to little more than six years in the days before insulin. Even at age fifty the improvement is sizable, with an expectation of life of fourteen and one-half years today which is 50% more than in the pre-insulin era. And these added years of life are useful and active, not years of invalidism. Moreover, this great improvement in the active life of the typical diabetic is of particular importance, because the number of these persons in the population is actually increasing through the aging of the popula-

tion and through the increased survivals of younger diabetic patients to older ages."

This paragraph based on accurate statistics describes the complete realization of all that Banting and I hoped and planned for in the summer of 1921.

The war has had a favourable effect on the supply of pancreas for the production of insulin in the United States and Canada, since the amount of raw material shipped to Europe from the Western Hemisphere has decreased. But the diabetics of the occupied countries of Europe have suffered from a lack of insulin and for many cases there has been none available. Through the kindness of Sir Henry Tidy, President of the Royal Society of Medicine, London, I was given the opportunity, slightly more than a year ago, to discuss the insulin situation with the medical representatives of the "Governments in exile" of practically all the countries which were at that time occupied. The lack of insulin was only one of their many woes, but as some of them expressed it: "To have our children thrust back to before the 'insulin era' is hard to bear."

Matters have now improved. The Canadian Red Cross sent insulin to Greece, the first lot arriving not long after the German occupation. Several shipments have been made more recently. Supplies have now reached France and Belgium from various sources. Full details of the present situation are, of course, not yet available. Germany may have had adequate reserves of insulin for Aryan diabetics and certain satellite countries may have attempted to purchase unusually large amounts during this war.

There has been no lack of insulin in England but on one occasion two of their main supply depots were destroyed by bombs. An adequate amount of insulin powder was dispatched immediately by air from the United States and the situation was saved.

The Action of Insulin

As a bridge between what we know and what we hope to know about insulin, let us consider the mechanism of its action in the body. The broad, over-all picture seems bright and clear. The administration of insulin to the recently depancreatized dog or to the uncomplicated case of human diabetes, completely restores the organism and if the treatment is carefully continued and no accidents or complications occur, the patient may proceed with an essentially normal existence. If further proof were needed for this statement, the war has provided it, since, although diabetics are not accepted in the Services, a few have evaded their medical colleagues and have served as pilots over Germany with the Royal Air Force, as captains of ocean liners during the worst of the submarine menace and in other positions of great responsibility.

We, as medical men, have been greatly impressed by the scientific accomplishments of our diabetic medical colleagues—the greatest of these is the liver treatment of pernicious anaemia, in the discovery of which Dr. George Minot was the senior partner. Many diabetic physi-

cians* treat the condition which they have learned to control in themselves. My friend Dr. Robin Lawrence has set a fine example during the war, as he did before it, to his fellow members of the British Diabetic Association, the President of which is Mr. H. G. Wells (who writes that he has found diabetes "an invigorating diathesis").

The detailed mechanism of the action of insulin is by no means as clear as its specific effect on diabetes might suggest. We soon learned that the formation of the key polysaccharide glycogen was stimulated by insulin and that the burning of sugar was accelerated. The wasteful and dangerous breakdown of protein to sugar and fats to ketone bodies in the liver, was checked. More recently direct evidence of an action previously postulated, *i.e.*, the acceleration of the formation of fat from sugar, has been obtained. It is now possible to label the sugar molecule and in part, to follow it while it is changed to fat under the influence of insulin. Some of the phosphate compounds of paramount importance in provision of energy for muscular contraction hasten their rate of interchange when insulin is present. Thus we know many interesting effects of insulin but we have much more to learn before the picture is complete.

The Prospects

The prospects of obtaining more complete knowledge of the action of insulin and of improving in many ways the treatment of diabetic patients, are very bright.

The intelligent use of such labelling agents as radioactive phosphorus and the stable isotopes of carbon, nitrogen, sulfur and other elements, is certain to illuminate many of the dark passages through which insulin passes in producing its effect on diabetes. We can confidently expect further advances in this field which has been widened and cleared even during this war.

The fact that in the diabetic patient or in an experimental animal, eight-tenths of the insulin-producing capacity may have disappeared before it is possible to detect this by any procedure except direct examination, which of course is not feasible in a patient, presents a challenge to clinician and experimentalist alike. It is inconceivable to me that a clear-cut problem of this kind can long resist the onslaught of fresh and vigorous minds which we hope will attack it and other "Islands of Resistance" when peace comes. There are many physiological and chemical avenues of approach which have not been explored.

We have no reliable methods for the estimation of insulin in small quantities of blood. Mastery of this technique would help in diagnosing the type of diabetes and perhaps in the treatment. We need either a sensitive and specific chemical test or a microbiological procedure which is capable of detecting the small amounts of the antidiabetic hormone which are certainly present in varying quantities in blood. Relatively few vigorous attacks have been made on this problem.

Experimental evidence suggests

*Including the first physician treated with insulin—Dr. Joseph Gilchrist of Toronto.

that diabetes may be produced by an excess of the secretions of the anterior pituitary or adrenal glands. We must develop accurate procedures for the assay of these diabetogenic materials in blood. It has already been shown that diabetes may be most favourably affected by removal of the exciting cause which has been found in a few clinical cases in one of the adrenal glands.

We can look forward with confidence to the development of better diets for diabetics. A lead has been supplied recently by English workers who, confirming the well-known favourable effect of diets rich in fat on the diabetes of experimental animals, have suggested that certain fats may be used as a source of energy without the production of excessive amounts of the dangerous ketone bodies. The role of some of the new accessory food factors on the intensity of diabetes is just beginning to be studied and the use of small animals made diabetic by the injection of alloxan, a chemical which selectively destroys the insulin-producing cells, will be of great value.

We know that there will be better control of infections, which produce the main problems in the treatment of many diabetics. Penicillin by its gentle and effective action should introduce a new era of progress in relation to the control of infection in diabetic patients.

The problem of giving insulin in a more physiological way presents many difficulties. It will not be easy to make a compound of insulin which is susceptible to the sugar content of the tissues. This compound should free insulin more rapidly as the sugar content of its environment increases and thus simulate conditions in the normal pancreas. Improvements over protamine zinc insulin are quite possible and should certainly engage the attention of those who have already made such strides in this field. Insulin by mouth for mild cases of diabetes is by no means an impossibility although it will probably always be a wasteful procedure and perhaps a hazardous one, when the dose of insulin must be very accurately regulated.

Perhaps there is some short cut to the synthesis of insulin or perhaps only certain of the chemical groupings in the complicated formulae are necessary for the antidiabetic effect. We may well have to utilize the large amounts of insulin which could be collected from the bony fishes who manufacture and store their insulin in a organ devoted exclusively to this task. Perhaps some of the more primitive but readily available forms of life make something which is either insulin or which can be readily transformed into it.

In many of the chronic cases of diabetes, the insulin-producing capacity of the islet cells is irretrievably lost and we can work only to improve the replacement therapy, *i.e.*, the procedures by which insulin is given. In the mild or new cases and perhaps in some of the older patients, there is hope that a cure will be discovered. This problem, and the prevention of the disease, are two of the most urgent ones which face workers in this field.

In experimental animals the diabetes resulting from the partial re-

moval of the pancreas or from the administration of the diabetogenic hormone of the anterior pituitary gland may now, under certain conditions, be prevented or in its early stages cured by the appropriate use of insulin and diets which do not tax the capacity of the reamining islets of Langerhans.

The prevention and cure of diabetes in experimental animals arouses hope that application of similar procedures may some day be made in the human subject. This will not be easv until the potential human diabetic can be recognized much earlier than is possible at present and until much more light is thrown on the etiology of the diabetic state in man. In spite of the obvious difficulties I have no doubt that some enterprising clinician will determine, by actual trial, the extent to which the results of the animal experiments are applicable to the human subject. In the meantime further experimental research may help to clarify the situation.

In conclusion, the experiments begun in May, 1921, resulted in the isolation of the anti-diabetic hormone, the administration of which to completely depancreatized dogs, restores these animals to perfect health, which can be maintained indefinitely. A great deal has been learned about the action of insulin. The purification of the active principle has made available the pure crystalline insulin protein. The clinical application of the experimental findings, dating from January 11, 1922, has created an ever-increasing demand for insulin.

Many of the gains made in the field of insulin and diabetes are well consolidated but a host of new problems, on a much broader front have appeared. This is a healthy situation which should attract many young minds in what we hope will soon be a great post-war period of medical research.

Western Waste Lands

➤ THE RECLAMATION of millions of waste acres, particularly in 17 arid or semi-arid western states, offers the opportunity to provide much-needed, fertile fields for the production of food required to keep pace with growing world needs, Kenneth W. Markwell of the U. S. Bureau of Reclamation declares.

There is great need for rebuilding the soil, bringing under cultivation new acres that can be farmed economically, harnessing rivers for power, flood control and navigation, and in addition "utilizing to best advantage every drop of water in the West."

In contending that reclamation of the West is essential for a better-fed and healthier America, Mr. Markwell asserted that conservative estimates based upon studies made by the U. S. Department of Agriculture forecast the necessity for bringing about 40,000,000 new acres of land under cultivation by 1960 to replace marginal and sub-marginal land to meet the needs of a growing population and to supply normal export markets.

Aniline and the Dye Industry

by Burton L. Hawk

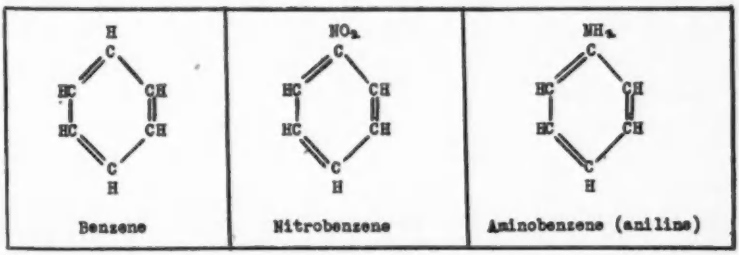
➤ It was in 1826 that the chemist, Unverdorben, distilled indigo and obtained a new compound. But little was learned concerning the new compound and it was not considered to be of much value.

Eight years later the chemist, Runge, obtained the same compound from coal tar. But, again, little was known about it and it was considered more or less useless.

But in 1856 the chemist, Perkin, while searching for a method to prepare quinine synthetically, accidently discovered a use for the substance. During the course of his research, he poured chromic acid in a container which held some of the "useless compound" obtained from coal tar. No doubt he was greatly surprised to see the deep violet color which diffused rapidly throughout the container. This was *mauve*, the first of the many colorful aniline dyes, which the chemist now prepares from black, sticky, foul-smelling coal tar.

You can prepare aniline in the home laboratory and repeat Perkin's experiment. This can be done using benzene as the starting point, from which nitrobenzene is prepared. The nitrobenzene is then reduced to aniline with nascent hydrogen.

Carefully mix together 3 ml. of con. sulfuric acid and 3 ml. of con. nitric acid. Cool the solution and add it in small portions to 2 ml. of benzene in a small flask. Shake the flask thoroughly after each addition. When all has been added, warm the flask *gently* for a few minutes. Nitrobenzene is formed and can be recognized by its characteristic almond-like odor. Inhale cautiously as the vapors are poisonous. Pour the mixture into 10 ml. of water in a test tube. The nitrobenzene will separate as a light yellow oily liquid. Transfer this liquid to another test tube by means of a medicine dropper. Add a small piece of tin and 5 ml. of hydrochloric acid. If the reaction is too slow, it can be



hastened by gentle heat. (Shake the tube occasionally). Nascent or atomic hydrogen is liberated and reduces the nitrobenzene. The light yellow liquid gradually turns darker in color. If necessary add more tin or acid to assure ample generation of hydrogen. The aniline obtained in this manner is dark brown with a benzene-like odor.

The beautiful mauve dye is formed when an oxidizing agent is added to aniline. Perkin used chromic acid, but bleaching powder is generally used now because it is cheaper and more readily available. Stir about one teaspoonful of bleaching powder (chloride of lime) in 200 ml. of water. Add to this one drop of aniline. Immediately the purple color is formed and gradually spreads throughout the solution. Filter, and take notice of the clear solution. It will appear wine-red in strong light. Various dilutions will produce many lovely hues of violet. Before disposing of the dye, add a solution of sodium bisulfite to it. Perhaps the result will surprise you!

The chemistry of the above reactions can easily be understood if the formula for nitric acid is visualized as $OH.NO_2$. Now the hydroxyl radical (OH) has a strong attraction for the hydrogen atom (H). The latter is readily available in the benzene molecule. (Refer to accompanying diagram.) Thus the two unite to form a somewhat common substance with the formula, H_2O. This leaves the nitro group (NO_2) alone, which immediately combines with the carbon from which the hydrogen was snatched by the hydroxyl group. The new combination is nitrobenzene. When aniline is formed, the oxygen in the nitro group is replaced by hydrogen to form the amino (NH_2) group. The oxygen that is set free immediately combines with more of the hydrogen to form the substance H_2O. And that's all there is to it! Nothing really complicated about it, is there?

Synthetic Tanning Chemical

➤ A NEW TANNING compound for sole leather, developed synthetically by chemists, is believed by them to be superior to the natural product formerly obtained from chestnut trees. It is an important development because the natural chestnut material is no longer available domestically, most American chestnuts having been killed by a blight.

This synthetic tannin was developed by chemists of the Monsanto Chemical Company, which claims that it imparts to sole leather a fine, smooth grain as well as desirable qualities of tightness, firmness, pliability, and excellent resistance to abrasion, water and wear.

The chemical composition of the new tannin is not announced. It is, however, made from domestic raw material, and was developed by examining the complicated molecular structure of natural tannin extracts, and then creating a new product through chemical synthesis. In the development, chemists of the Monsanto Company and the University of Cincinnati leather research laboratory cooperated.

Age of Uranium Ores Supports Giant Atom Theory

The Universe Began as an Explosion

by Dr. Frank Thone

▶ Atomic explosions that wipe out whole cities in an instant seem awesome on a human, plentary scale. Seen from a cosmic grandstand, however, they are scarcely even sparks from a single powder-grain in the grand pyrotechnics of the universe.

Indeed, according to one bold theory, the whole visible universe, with great pinwheel galaxies containing millions of flaming stars, and with possible swarms of planets like the earth that have never been seen and only lately have been rather vaguely guessed at, got its start as a single super-atom of unimaginable energy content, that exploded a couple of billions of years ago—and is still exploding. All the energies of which we are aware, from the bursting brilliance of giant stars that far outshine our sun down to the feeblest kicks of a dying protozoon, are but the varied expressions of that vast primal explosion, if this hypothesis holds good.

The idea started with the notion of an expanding universe. Light from remote stars and galaxies, caught in astronomers' instruments, is redder than it theoretically should be. One explanation of this so-called red shift is that all parts of the visible starry universe are rushing away from each other at terrific speeds—much faster than the pieces of an exploding bomb.

About 15 years ago a young Belgian priest-scientist, the Abbe Georges Lemaitre, boldly suggested a backward extension of this expanding or exploding universe. Mathematical calculations carried him back to a beginning-point where neither time nor space existed, and all the matter that eventually came to constitute all the stars and planets was present only potentially, as terrifically high-level energy in one single cosmic atom.

Chemical elements as we know them are discussed in terms of their atomic weights and atomic numbers, which are expressions of the numbers of electrons spinning around the sun-like nucleus or atomic heart. Since the number of electrons in the smallest pinpoint of ordinary matter—a single dust-grain, for example—must be reckoned in trillions, the atomic number of this primordial atom is simply unimaginable. We have to call it infinity and let it go at that.

What the first atomic explosion was like is also something that defies human imagination. What set it off is doubtless forever beyond our guessing. Theoretical considerations have led the Abbe Lemaitre to a tentative conclusion that it must have occurred something like two billion years ago.

If these dizzying ideas are valid, our most terrifying "city-buster" bombs are made of mere pinches of debris from the universe's first enormous outburst, scraped up out of overlooked corners like a winter's last snowballs.

Ultraviolet Light Increases Yield
Methods of Synthesis Studied

Penicillin Progress

Latest advances in the study of this curative principle are reported from several centers where research on its production and chemical structure are in progress.

➤ THE NATION'S penicillin supply may be doubled as a result of ultraviolet treatment of the spores of the mold that produces the powerful anti-germ remedy, the Wisconsin Alumni Research Foundation announces.

Ultraviolet irradiation, it is explained, causes incompletely understood and unpredictable changes in the genes of spores and seeds with resultant changes in the characteristics of the plant or fungi springing from them. X-ray treatment does the same thing.

Treatment of succeeding generations of spores of Penicillium has resulted in a strain that produces nearly 1,000 units of penicillin from every cubic centimeter of broth in which the mold is cultured. In 1940, the yield obtained by the British workers was about two units from the same amount of broth culture.

The two-unit yield was increased to an average of 169 by efforts at the U. S. Department of Agriculture's Northern Regional Research Station at Peoria, Ill. Then Dr. Millislav Demerec, director of the department of genetics at Carnegie Institution, Cold Spring Harbor, N. Y., developed a group of promising spore variants by X-ray treatment.

This stepped up the yield to an average of 369 units. Descendants of these spores were exposed to ultraviolet light by Prof. Myron P. Backus and Dr. John F. Stauffer, University of Wisconsin botanists. The yield increased to an average of 761 units, with a high of 904.

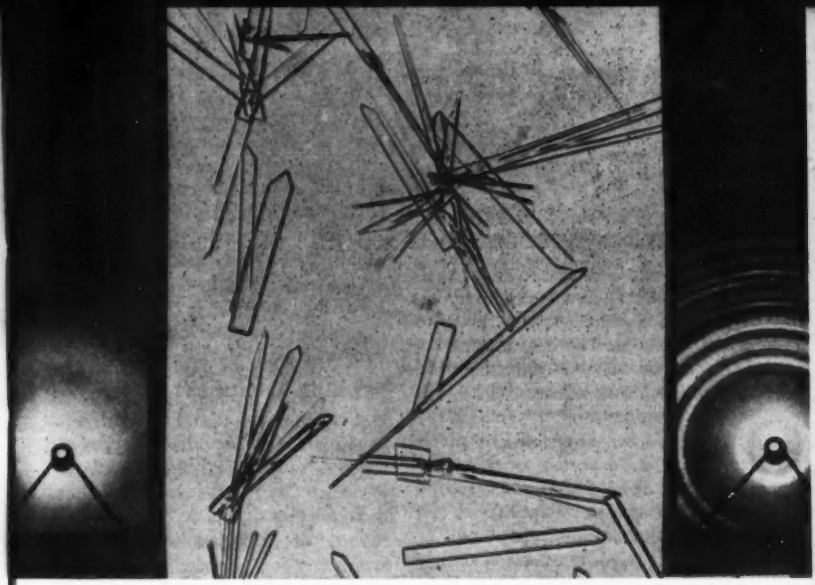
The hunt is still on for an even more efficient producer of penicillin. A strain that can produce two or five times as much of the remedy is a possibility, because the present high yield probably represents less than 1% of all the chemicals produced by the mold, while other molds are known to produce chemicals as complex as penicillin in quantities equal to 5% or 10%.

Scientists besides those named who have worked on the project at the University of Wisconsin include: Prof. William C. Frazier, Prof. Elizabeth McCoy, Prof. W. H. Peterson and Prof. Marvin J. Johnson. The work has been supported partly by Federal funds and partly by the Wisconsin Alumni Research Foundation.

Soil cultures of the new high-producing strain, called Q176, and unpatented, are being supplied gratis on request to penicillin manufacturers in this country and in England, France, China and elsewhere.

A Molecule of Water

➤ A MOLECULE of water stands between success and failure to synthes-



▶ CRYSTALLIZED PENICILLIN *is now on the market in the form of the sodium salt. The crystals, white in color, are shown above as they appear under the microscope. The X-ray diffraction pattern, on the right, also shows the crystalline nature of the material contrasted to the appearance of amorphous material of similar constitution, shown on the left. The new product is stated by its manufacturers, the Commercial Solvents Corporation, to have a potency of 1400 to 1500 units per milligram, while its stability makes refrigeration unnecessary. It is, of course, obtained from mold-produced material.*

ize penicillin, Dr. R. B. Woodward of Harvard University told members of the American Association for the Advancement of Science recently.

Dr. Woodward is one of two young chemists who in 1944 performed the difficult feat of synthesizing quinine.

Penicillin, he declared, has not yet been synthesized except in micro amounts which can be detected by their effect on disease germs but are not yet available in the form of pure crystals. As an organic chemist, he believes that penicillin can be synthesized on a practical scale.

The trick seems to involve removing that molecule of water from another chemical, penicilloic acid. This acid is penicillin plus one molecule of water. When chemists got as far as penicilloic acid in their attempts to produce penicillin in the laboratory during the war, mold production of the drug was far behind the need for it. They thought then the problem was solved, because penicilloic acid

can be synthesized easily by about a dozen different methods, a number of which are commercially practical.

Removing the molecule of water to produce penicillin seemed easy, but for two years it has stumped leading chemists in forty laboratories in this country and England.

The chemical structure of penicillin is known. It is a beta lactan. At first chemists rejected this structure for penicillin because beta lactans are very solid compounds whereas penicillin breaks down easily into a number of different chemicals. X-ray pictures of beta lactans, however, showed an unsuspected weakness in their structure. It might be called a bent or twisted molecule. With its two parts on different planes, and at the bend or twist, one part can easily break off to form all the compounds which penicillin becomes under various chemical treatments.

One of the parts that breaks off when penicillin is given these chemical treatments is penicillamine. This is the part of penicillin that is effective in stopping disease germs. The rest of the compound is like the hilt of a dagger, useful for getting the killing edge to the scene of action.

Penicillamine stops germs by competing with either valine or cysteine according to present theories. These are amino acids needed by disease germs for food. Pencillamine from penicillin therefore may kill the germs by starving them through depriving them of necessary nourishment.

Even with fairly plentiful supplies of penicillin available from mold production, a synthetic product would have the advantage of being pure penicillin. The commercial penicillin now on the market may contain as many as four different penicillins, some of which are more effective remedies than others. Artificial production of one or another of these penicillins in pure form is now being attempted by forced feeding of the mold. This involves adding to its nourishment certain chemicals which will force or enable it to produce penicillin G or X or one of the other two varieties.

Syphilis Treatment

➤ PENICILLIN is the best and safest treatment for syphilis yet devised. Patients who have been treated with it during the past several years and their doctors need not be alarmed by reports of its being ineffective, the syphilis study section of the U. S. Public Health Service declared in a statement.

Military secrecy necessary during the war was responsible for some of the confusion over penicillin and its effectiveness in treating syphilis. During the war only a very few persons were allowed to know anything about the chemical studies of penicillin. Those studies revealed the fact that there are at least four kinds of penicillin, called G, X, K and F in this country.

Manufacturers, meanwhile, were producing penicillin as fast as they could and were trying, quite laudably, to make their product as pure as possible. In the course of these efforts to get more and purer penicillin, they began getting and marketing penicillin containing substantial amounts of penicillin K.

Penicillin K, Dr. Alan Chesney of

Johns Hopkins Medical School announced in mid-February of this year, is completely ineffective in treatment of syphilis in rabbits.

That bombshell startled scientists and manufacturers. A meeting was called in Washington. Immediately after, manufacturers began taking steps to decrease the amount of penicillin K in their product.

Dr. Chesney's studies were made with pure penicillin K. Commercial penicillin, however, has not consisted of pure K. So patients treated with the commercial product, even since 1944 when K was predominant in some of the penicillins marketed, probably got some of the other kinds as well as K. They may relapse or they may not. If they relapse, they can be treated again.

They are in no more danger of getting paresis, or syphilis of the brain, than if they had been treated by any other method, Dr. Joseph Earle Moore, of Johns Hopkins Medical School and chairman of the syphilis study section of the U. S. Public Health Service, declared in discussing the situation at the National Academy of Sciences meeting.

Less than one in a hundred are in danger of getting paresis, he said.

Every patient with syphilis should return for retesting at regular intervals throughout his life, no matter what treatment he has had, Dr. Moore continued.

Patients treated at the U. S. Public Health Service rapid treatment centers are routinely asked to return for retesting. This has nothing to do with whether or not they were treated with penicillin. If on retesting it is found that any have relapsed, they will be retreated.

Larger doses of penicillin given at more frequent intervals are suggested by Dr. Moore as one way doctors can be sure they are giving their patients enough of the drug at present while there is any question of its containing much of the relatively ineffective penicillin K.

Penicillin K, he said, is one-tenth as effective as penicillin G in syphilis. It is one-sixth as effective as G in treating pneumonia in mice and one-fourth as active as G in treating streptococcus infection in mice. Patients with these acute infections, however, are not in any danger of not getting enough penicillin to get them well.

The reason penicillin K is less effective than the other varieties is that it is more rapidly destroyed in the body.

Resistance to penicillin which some disease germs have developed and the difficulty in curing subacute bacterial endocarditis, a chronic heart ailment, with penicillin may both be due to the increased amounts of K in penicillin since 1944, Dr. More said.

May Fail When Swallowed

➤ Penicillin X, an especially powerful penicillin for checking disease germs, may fail to cure a patient if he swallows the drug instead of getting it by hypodermic needle injection.

Tests showing this are reported by Drs. Manson Meads, Edwin M. Ory and Maxwell Finland, of Boston City Hospital and Harvard Medical School, in a recent issue of the journal, *Science*.

Germs causing gonorrhea, meningitis and blood poisoning were from

two to eight times more vulnerable to penicillin X than to penicillin G, the doctors found from test tube experiments comparing commercial lots of penicillin containing more G or more X.

Injections of penicillin X gave a higher level of penicillin activity in the blood than injections of penicillin G. But when the two kinds of penicillins were swallowed, the effect was reversed. The results suggest that that penicillin X is not absorbed as well as penicillin G when given by mouth.

Penicillin Controls Carriers

➤ PENICILLIN can help check epidemics of streptococcus sore throat and possibly other streptococcus-caused diseases, which include scarlet fever, it appears from a report by Dr. Morton Hamburger, Jr., of Chicago, and Capt. Henry M. Lemon, of the Army Medical Corps, in a recent issue of the *Journal of the American Medical Association*.

The mold chemical can do this because it can in many cases promptly eliminate all the streptococci from the noses and throats of healthy carriers of these germs. Spread of the germs from patients can be pretty well checked by isolation of the patients. Healthy persons who have the germs in their noses and throats are usually not known to be carrying the germs until they have spread them to many others.

Sulfadiazine can check the spread of streptococci from carriers if the streptococci are susceptible to the sulfa drug. Some strains of these germs, however, become resistant to sulfa drugs.

Pencillin in beeswax peanut oil, injected once a day for five to seven days, promptly eliminated the streptococci from both nose and throat of half the carriers in the group Dr. Hamburger and Capt. Lemon studied. In the other half, the streptococci were eliminated or reduced by more than 98% in number during the period the carriers were getting the penicillin, though after it was stopped, there was a relapse into the carrier state. Most of the carriers in whom relapse occurred, however, scattered very few streptococci into their environment.

"A method is now available," the two doctors conclude, "for controlling well over half the dangerous carriers in event of an epidemic."

Larger doses of penicillin, they suggest, may eradicate the carrier state from even more persons.

Dairy Cattle Disease

➤ PENICILLIN has more curative power than any other tested drug for common mastitis, the most prevalent disease among dairy cattle.

Used in three large doses of 50,000 units each, at 24-hour intervals, penicillin cured 92%, in University of Wisconsin tests. Single large doses cured about half the cases, and more where the infection was not serious or of long standing.

The drug proved generally helpful for dry and milking cows, causing little irritation, and had no apparent effect on milk production. It was more valuable in chronic cases than in acute flareups.

The tests were conducted upon mastitis caused by a streptococcus, which is the most common form. The vet-

erinary scientists at the University of Wisconsin stated that other forms of the disease may respond better to sulfa drugs than to penicillin. Dairymen were advised to rely on a veterinarian's diagnosis.

With cows of average value it will often be practical to try first a single treatment with 50,000 units. If that fails, and the animal is valuable enough, a series of treatments can be used, administering three treatments of 50,000 units each at 24-hour intervals.

The University scientists emphasized, however, that drugs can only cure, and will not prevent the disease or reinfection with it, thereby making it as important as ever to hold mastitis to a minimum by practicing strict sanitation.

"Dr. Pep's Vitamin Laboratories. Yippee."

Atomic Tracer Tracks CO Use

➤ ATOMIC "TRACER" research indicates that carbon monoxide cannot be utilized by the human body in combination with oxygen to form carbon dioxide.

The research, performed by the University of California Aero-Medical Unit and recently removed from the war secrets list, was done with radioactive carbon monoxide produced in the 60-inch Berkeley cyclotron.

Purpose of the experiments was to determine whether the safe level of carbon monoxide in airplane cockpits, tanks, etc., could be changed in favor of higher tolerance. The research did not indicate this could be done.

Human subjects were allowed to breathe radioactive carbon monoxide followed by 100% oxygen. A bag containing soda lime was then placed over their mouths. In the event carbon monoxide was combined with oxygen to form carbon dioxide, the radio carbon in the latter would be collected from the breath in the lime.

Only a negligible quantity of radio carbon was collected, so little in fact that it indicated no carbon monoxide was utilized in the formation of carbon dioxide.

Short-lived radioactive carbon, known as Carbon 11, was used in the experiments. This isotope of carbon has a half-life of only 21 minutes, allowing experimenters only a few hours to work with it.

The researchers are withholding final judgment on the formation of carbon dioxide until experiments can be done with long-lived radioactive carbon, known as Carbon 14. With this isotope, long and complicated experiments can be done.

The research was done by Dr. John Lawrence, who was head of the Aero-Medical Unit and who has returned to peacetime research as head of the biological research program in the Berkeley radiation laboratory, and Dr. Cornelius Tobias, a member of the laboratory staff, in collaboration with Dr. F. W. J. Roughton, Dr. Walter Root, and Dr. Magnus Gregersen, of Columbia University. Dr. Joseph G. Hamilton, of the radiation laboratory, prepared the radio carbon monoxide. The work was done under an OSRD contract .

Tensile Strength of Cotton Yarn Increased

➤ COTTON YARNS are given additional strength by the application of a new chemical, members of the American Association of Textile Chemists and Colorists were told at a meeting in Winston-Salem, N. C., recently by Dr. Donald H. Powers of Monsanto Chemical Company. The tensile strength of the yarn may be increased up to 40%, he declared.

The improvement is effected through mill applications of a special submicroscopic colloidal silica called Syton, he said. This chemical was developed by the company to make sheer stockings run-resistant and to take the shine off serge. When applied to cotton sliver in concentrations of 1% to 3%, the inter-fiber friction is increased and it was possible to increase the tensile strength and to decrease the twist as much as 40%.

Chemical Things To Do

Darkroom From Cardboard Box

by Joseph H. Kraus

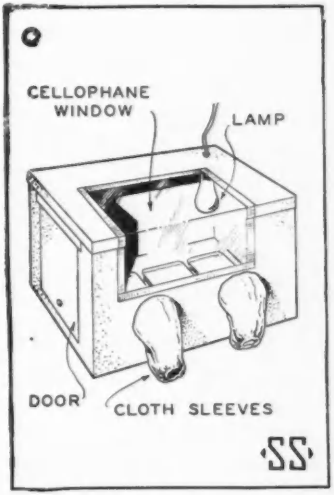
➤ A COLLAPSIBLE, portable darkroom in which you can comfortably develop film and make contact prints at any hour of the day is made easily from a cardboard box.

To determine the size of the box you need, set your empty developing trays just as you like to have them when working and measure the overall size. A box 18 inches by 24 inches and of a convenient height readily will accommodate three five- by seven-inch trays, and even three eight- by ten-inch trays can be squeezed into the same space.

A typical knock-down corrugated box is preferable because you can fold and store it away when your job is done, but a two-piece box will work just as well.

If you want a box in which to develop films, you can place your developing trays on the top, and invert the rest of the box over it. Or the box can be made with a door cut in the left side and hinged with a piece of adhesive tape. Use cardboard strips to make it light-tight. The door should be large enough to let the developing trays, tank and printing frame pass in and out.

Cut two four-inch circular openings for your hands about 18 inches apart. Make two elbow-length sleeves of black cloth, tapering them slightly. Sew a hem at the smaller end into which you can run a short length of elastic: if you have no elastic, use one or two rubber bands cut and tied together.



Run a circle of iron wire, obtained from a thin discarded coat hanger, through a hem at the opposite end to keep the sleeve from coming out of the box. Attach the wire loop to the box with strips of adhesive paper either from the inside or the outside. If you find it difficult to hold the ring in place, you can either sew it to the box or use another cardboard disk as an attaching washer. In use, the sleeves may be employed as illustrated in the accompanying diagram or they can be turned into the box.

Be sure to cover all holes and other sources of light as your work will be

done without light. Working entirely by feel, your clock and the temperature of the solutions will tell you when the film has been properly developed.

A Safe Window

If you wish to develop paper in the miniature darkroom, you will need a colored transparent opening so that you can see the prints develop. The light which normally comes through this window must be safe for the paper used. Get a sheet of dark, orange-red cellophane for the window. If this is not available, you can use a sheet of gelatin film similar to that employed for stage lighting. A third option is to use a sheet of discarded X-ray film from which the emulsion has been removed.

To prepare the X-ray film, get a package of gelatin from the grocery store and a package of orange-red dye from the 5- and 10-cent store. Prepare the gelatin according to directions, add enough of the dye to give the desired color, and stir. While still warm, dip the film in the dyed gelatin or brush it on with a soft brush. Hang the film by one corner to dry.

Before you put your film in the window, test it as follows. In the dark put your film over a sheet of unexposed printing paper, the back of which is protected with cardboard or a print frame. Carry this to the daylight where the box is to be used and let the light shine through the film onto the paper for 10 minutes. If the paper shows any traces of fog after it is developed, you will have to darken the color of the film by heating the gelatin, adding more dye and redipping.

The sheet of film will determine the size of the window. Lay it on the box, approximately as indicated in the diagram, allow for a one-inch overlap, and fasten to the cardboard with gummed paper strips.

Pass a lamp into the box, permitting the cable to run through a hole or alongside the corner where the box joins. The 60-watt white light is used for exposing the printing paper under the film in the printing frame. It is turned out for developing. The outside light is enough to see by.

The same box may be used for film by simply covering the window with your coat or some opaque material. Develop the film, with no light in the box, by the time-temperature method.

Answers to Chem Quiz on Page 13

➤ Specific uses for the metals listed are: copper for electricity, magnesium for flashes, radium to treat cancer, strontium for red fireworks, mercury for thermometers, zinc to galvanize iron, iridium for fountain pen points, cerium for lighters, selenium for photo-electric cells, beryllium to emit neutrons when bombarded, plutonium for atomic bombs (better than uranium), chromium to make things shiny, gold for monetary standard (well, it used to be), tin cans for food, lead for storage batteries, arsenic for poisons for man or beast, insect or fungus (ask your farmer).

Product Like Maple Syrup From Tree Native to Burma

Sugar From Toddy Palms

➤ Sugar from the toddy palm, which tastes like maple syrup, is used by natives in the semi-arid sections of upper Burma. Toddy sugar is preferred by the Burmese to imported cane sugar, and in peacetime a million dollars' worth is exported each year to India.

Toddy palms look like the palmettos of Florida, but are much taller, sometimes being 80 to 100 feet high. Sugar is made during the dry period from January to April. That made during the first part of the season is always better than the sugar made immediately before the rains.

"Sap is taken only from the female trees, which are not allowed to bear their miniature coconut-like fruit during the sugar season," states Dr. Barnum Brown, of the American Museum of Natural History.

The flower stalks of nearby male trees are cut off or tied up, so that their pollen cannot be dispersed. The flower stalks of the female trees, usually growing two or three clusters on each tree, are carefully tied in long rolls so that they cannot open. The ends are cut off, allowing the sap that would normally form nuts to trickle out drop by drop. An earthen jar is suspended under each flower stalk to catch the drip.

The fresh juice is mildly sweet and rather insipid, but changes rapidly in taste if allowed to stand six or eight hours. When fermentation begins, the flavor changes from hour to hour, and at some stages it is a delicious beverage. The fermented toddy juice, a mild intoxicant, is a favorite drink of the Burmese.

The sap gatherer, with a collecting jar or two slung from his girdle, visits each tree morning and evening. The drip jars are emptied into these, and a thin slice is cut from the end of the flower stalk at each visit, so that it will continue to bleed freely when the drip jar is again tied in place.

The sap is boiled over a slow fire until it crystallizes. After cooling, it is molded by hand into small round balls. As much as a pound of sugar can be produced from two gallons of sap, Dr. Brown reports.

Teachers to Meet

➤ The New England Association of Chemistry Teachers will hold its annual meeting August 19-24, 1946, at Middlebury College, Middlebury, Vermont.

Sincerity of Scientists Stressed at UNO Meeting

Experts Handle Atom Negotiations

by WATSON DAVIS

➤ IT IS A WARM and encouraging scientific fact that sincerity is the prime ingredient of the USA proposals to the UNO atomic energy commission. The scientists to whom I have talked are convinced that Mr. Baruch speaking with high authority means what he says on behalf of the nation. Delegates from other nations and their scientific advisers can take the proposals at face value. If this be something unusual in world diplomacy, so much the better.

One of the great dangers to discussions that have begun is that blundering although highly patriotic individuals may give the impression that the United States will not carry through in turning over to the proposed UNO atomic development authority the stocks of bombs, the atomic energy plants and the secrets and know-how.

The fact is that this building of a world atomic energy structure is being approached as a scientific problem. The little groups of atomic scientists from all over the world who gather over luncheon tables or at cocktails remind me of a world conference on science. Much of the real work of the conference will be done, of necessity, by these scientists who are the experts.

Some of them, like Dr. M. L. E. Oliphant, Australian adviser although he worked in England during the war, Sir James Chadwick of Britain, Dr. Richard C. Tolman, Dr. Harold Urey, Dr. J. Robert Oppenheimer and others of the U.S. group, have been used to working together. Others, like Prof. D. V. Skobeltsin, the Soviet physicist and adviser, and Prof. H. A. Kramers of the Netherlands, were not in on the wartime researches that created the problem. A great pioneer in atomic physics, Prof. Frederic Joliot Curie of France, who was very busy at home during the war, is also making his first contacts with current details.

From Chicago there is being begun another attempt to convince scientists of other nations of America's strong determination for peace. Every American scientist who knows a foreign scientist is being urged to write to him in support of the international control of atomic energy program. Already this plan, backed by the Federation of Atomic Scientists, has started a thousand such letters on their way.

Chemicals from seaweed will be produced on a large scale in a new adventure by a British firm in the islands of South Uist and Benbecula in the Hebrides.

State Department Report
Concluding Section

International Atomic Control

This survey of how the world can cope with atomic fission originated with a Committee on Atomic Energy set up by Secretary Byrnes on Jan. 7, 1946. This committee called on a Board of Consultants chosen from organizations which had a hand in development of the atomic energy program. The Board wrote the report. Part I of the report, reprinted in the April issue of CHEMISTRY, *surveys the problem. Part II, reprinted in May, considers practical safeguards. In the first section of Part III, in June, the report outlines progressive steps by which international control can be achieved. This, the concluding section, emphasizes national safeguards while these steps are in progress.*

Policies

▶ UNTIL QUALIFIED MEN set themselves the task of actually writing a charter, chapter by chapter, anything said about policies must be merely by way of preface. The actual statement of policy, like the form of organization, will have to grow out of the international discussions and deliberations.

The fundamentals governing the Atomic Development Authority must of course be those which have been so well stated in the resolution of January 18, 1946 setting up the United Nations Atomic Energy Commission, that is, the strengthening of security and the promotion of the beneficial use of atomic energy. In our report we have adopted as the first principle in the accomplishment of these fundamental objectives the proposition that intrinsically dangerous activities in the field must not be left open to national rivalry but must be placed in truly international hands. To establish the boundaries between international and national action, we have grasped the fortunate circumstance that a dividing line can be drawn between dangerous and non-dangerous activities. We have emphasized that not the least in the fortunate circumstances that we have observed is the fact that the field of non-dangerous activities is so challenging that it provides an opportunity to avoid such centralization of authority as might make the price of security seem too high. In this connection it is important that a purposeful effort should be made to keep as broad and diversified as possible the field of activities which is left in national and private hands. Every effort must be made to avoid centralizing exclusively in the Authority any more activities than are essential for purposes of security.

These are the kind of basic considerations which we assume the United Nations Atomic Energy Commission would seek to make explicit in its recommendations for the charter of

an Atomic Development Authority. Many others can be added to the list. We mention some now which are typical and illustrative and which are drawn from the kind of questions which have arisen in our own discussions.

We would expect that the charter itself should, so far as practicable, define the areas that are clearly dangerous, in which there must be an exclusive international operation, and the areas which now seem clearly nondangerous, in which there may be national and private operations. One of the most difficult problems will be the creation of charter provisions and administrative machinery governing the manner in which the line will be drawn between safety and danger near the middle of the spectrum of activities where the division becomes less sharp. Another difficult problem will be to provide the means to redefine as either "dangerous" or "safe" when new knowledge shifts the line. In these matters close questions will arise, of course, as to the issues which must be referred for approval to the individual nations, the issues which need only be referred to some organ of the United Nations, like the Security Council, and the issues which can be determined by administrative action of the Atomic Development Authority itself.

In strengthening security, one of the primary considerations will relate to the geographical location of the operations of the Authority and its property. For it can never be forgotten that it is a primary purpose of the Atomic Development Authority to guard against the danger that our hopes for peace may fail, and that adventures of aggression may again be attempted. It will probably be necessary to write into the charter itself a systematic plan governing the location of the operations and property of the Authority so that a strategic balance may be maintained among nations. In this way, protection will be afforded against such eventualities as the complete or partial collapse of the United Nations or the Atomic Development Authority, protection will be affored against the eventuality of sudden seizure by any one nation of the stockpiles, reduction, refining, and separation plants, and reactors of all types belonging to the Authority.

This will have to be quite a different situation from the one that now prevails. At present with Hanford, Oak Ridge, and Los Alamos, situated in the United States, other nations can find no security against atomic warfare except the security that resides in our own peaceful purposes or the attempt at security that is seen in developing secret atomic enterprises of their own. Other nations which, according to their own outlook, may fear us, can develop a greater sense of security only as the Atomic Development Authority locates similar dangerous operations within their borders. Once such operations and facilities have been established by the Atomic Development Authority and are being operated by that agency within other nations as well as within our own, a balance will have been established. It is not thought that the Atomic Development Authority could protect its plants by military force from the

overwhelming power of the nation in which they are situated. Some United Nations military guard may be desirable. But at most, it could be little more than a token. The real protection will lie in the fact that if any nation seizes the plants or the stockpiles that are situated in its territories, other nations will have similar facilities and materials situated within their own borders so that the act of seizure need not place them at a disadvantage.

Various auxiliary devices, in addition to a strategic geographic division of plants and facilities and stockpiles, will also be necessary. Some of these have already been referred to. The design of primary production plants should make them as little dangerous as possible. The stockpiles of materials suitable for the production of bombs should be kept as small as possible consistent with sensible economics and engineering. So far as practicable, stocks should be kept denatured or kept in low concentrations unsuitable for the production of bombs. In other words, the design and operating procedures should definitely prevent the accumulation of substantial amounts of material quickly convertible into important quantities of explosives.

All these matters must be the subject of the most careful consideration in the writing of the charter itself.

With appropriate world-wide distribution of stockpiles and facilities; with design rendered as little dangerous as possible; with stockpiles of dangerous materials kept at the lowest level consistent with good economics and engineering; there will be no need for a sense of insecurity on the part of any of the major powers. Seizures will afford no immediate tactical advantage. They would in fact be an instantaneous dramatic danger signal, and they would permit, under the conditions stated, a substantial period of time for other nations to take all possible measures of defense. For it should be borne in mind that even if facilities are seized, a year or more would be required after seizure before atomic weapons could be produced in quantities sufficient to have an important influence on the outcome of war. Considering the psychological factors in public opinion, the fixing of danger signals that are clear, simple, and vivid seems to us of utmost importance.

There are other basic problems of only slightly less difficulty which will also need to be dealt with in the international deliberations. These have to do with such matters as compensation to the nations and private agencies for the raw materials which the Authority would take over, they have to do with the problem of initial financing, they have to do with the allocations and distribution of the materials and the facilities which the Authority will license or sell to individual nations and, through them, to their citizens. One of the difficult problems in this respect will be the question of priority in establishing non-dangerous power plants within various nations and the relation between these licensed activities and the power-producing activities of the Authority itself. A special word needs to be said on this subject.

The needs of nations for new power resources vary not only with indus-

trial conditions, but also with their proximity to water power, coal, and petroleum. As we have emphasized before, the power supply from fissionable materials is of two entirely distinct kinds. Power will be produced in the very process of operating the production plants which make fissionable materials. These plants are of the dangerous kind which must be owned and operated by the Authority. The decisive consideration in determining the location of such plants will have to be strategic; otherwise the physical balance between nations will be impaired. In other words, the distribution of these plants throughout the world will have to be based primarily on security considerations. But there will still be ample room for an individual nation, once it is decided that such a plant can be located within its borders, to determine where the plant shall be situated in relation to its own economic and social needs. It also appears fair to assume that the charter could provide specifically for the Authority to turn the power over to the nation or its designee at the bus bar of the power plant, thus leaving it to each individual state to determine policy in relation to transmission, distribution, and use, or the Authority might deliver steam to the individual state, leaving all electrical operation in national or private hands as determined by the policies of the particular nation. Problems of price will be difficult, but here again it should be possible to state basic policies in the charter which will give reasonable assurance of fairness in the fixing of cost.

The problem of power producing piles should be somewhat less difficult in the case of the non-dangerous plants. In these, fissionable materials will be denatured. The charter should be able to provide for their allocation of this type of plant in accordance with more conventional economic standards. It might be possible to provide that they should be located on the basis of competitive bids among interested nations. On such a basis, countries with ample power resources in water, coal, or oil would limit their bids to those warranted by the costs of alternative sources. Those countries having few or expensive ordinary sources of power might bid higher, but below the cost of other alternatives. In this way the maximum usefulness of fissionable materials with the greatest conservation of other sources fo power would be secured.

Many other questions of the same order as those we have discussed can readily be imagined. These are enough to illustrate the nature of the problem.

Transition to International Control

➤ When fully in operation, the plan described in the previous section would, in our opinion, provide a great measure of security against surprise attack by atomic weapons. But it will take a considerable time before the plan can be adopted, and once the nations of the world have adopted it, a still further time will be required to put the plan into operation. It is essential to consider what will be the condition of aflairs during the necessary period of transition.

In particular we must take note of

the nature of the commitment already made for international action in order to determine whether the proposal satisfies the conditions attached to that commitment. In the pronouncements which the United States has made and sponsored in concert with other nations, the commitment for action has always been coupled with the requirement that the process of moving toward the goal of complete international collaboration must be accompanied at each stage by appropriate safeguards. It is the purpose of this section to describe the extent to which the suggested plan will satisfy this requirement.

The period of transition may be broken down into two sub-periods. In the first there will be no Atomic Development Authority. There will be discussions in the Atomic Energy Commission of the United Nations Organization, and as a result of these discussions, proposals will be referred to the United Nations Council and Assembly and to the several nations for further discussion and acceptance. From this process, there will result a charter that has been ratified by the various nations. It is at this stage that the Atomic Development Authority will come into being. All of this will inevitably require time. In the second period, when an Atomic Development Authority is created by the ratification by the several nations of the charter which establishes it, it will have an immense task before it, involving many different fields and many different activities. It would, of course, be possible to leave the ordering and sequence of these activities, or rather of undertaking them, to the discretion of the Authority. It seems far more likely that provisions governing the sequence of steps by which the Authority will come into full operation will be provided in the charter.

Two different kinds of consideration will be involved in setting up the steps of discussion and operation. On the one hand there are, as we shall see, certain indispensable requirements for the *adoption and the success of the plan itself*, which require that certain steps be taken before others can be effective. On the other hand, there is a wide range of schedules all equally compatible with the operability of the plan and *affecting primarily its acceptability* to the several nations. We shall be concerned in this section with outlining the requirements of the plan as to schedule, and pointing out what other elements are not fixed by the plan itself and in the fixing of which quite new considerations are essential. In other words, we shall attempt to describe those steps which must be undertaken in a particular order if the plan is to become effective at all. We shall also indicate other steps which are a necessary part of bringing the plan into operation, but as to which there is some freedom of choice in determining their sequence. The sequence of the first set of steps is fixed by the plan itself; the sequence of the second set is a matter that will have to be fixed by the negotiation between the nations.

The Position of the U. S.

In order to have meaning, the examination of the transition period must take account of the present position of the United States in the field of atomic energy, and that position

must be compared with the one that this country would occupy during the period when the plan for international action is being adopted and executed. Today's position must also be compared with the conditions that will prevail when the plan has finally been brought into full operation. We must also consider what our position would be some years hence if we were forced to abandon our present commitment for international action and pursue instead a purely national treatment of the problem.

Today the United States has a monopoly in atomic weapons. We have strategic stockpiles; we have extensive facilities for making the ingredients of atomic bombs and for making the bombs themselves; we have a large group of people skilled in the many arts which have gone into this project; we have experience and know-how obtainable only in the actual practice of making atomic weapons; we have considerable resources of raw material; and we have a broad theoretical knowledge of the field which may appear inadequate in future years, but which enables us to evaluate not only the performance of the past but also what the future is likely to hold.

It is true that some part of our monopoly we hold in common with the United Kingdom and Canada. This applies principally not to material facilities or to weapons, but the availability of raw materials, to theoretical knowledge, and to some elements of the know-how.

It has been recognized that this monopoly could not be permanent. There have been valid differences of opinion on the time which it would take other nations to come abreast of our present position, or to surpass it; but it is generally admitted that during the next five to twenty years the situation will have changed profoundly.

International control implies an acceptance from the outset of the fact that our monopoly can not last. It implies substituting for competitive development of atomic armament a conscious, deliberate, and planned attempt to establish a security system among the nations of the world that would give protection against surprise attack with atomic weapons. Above all, it involves the substituting of developments by the several nations which might well remain more or less secret, and where the very fact of secrecy would be a constant source of fear, incitement and friction.

Inherent in the adoption of any plan of international control is a probable acceleration—but only acceleration—of the rate at which our present monopoly will inevitably disappear, since our knowledge and our mastery of practical arts, and to some extent our physical installations, must ultimately be made available to an international agency in the process of establishing control.

Let us consider, for example, the plan we recommend in this report. If adopted and executed in good faith, this will have reached a reasonably full degree of operation in a period of years. At that time nearly all the factors making the present position of the United States in relation to atomic energy a preferred one will have been eliminated. For, when the plan is in full operation, no nation will be the

legal owner of atomic weapons, of stockpiles of fissionable material or raw materials, or of the plants in which they can be produced. An attempt will have been made to establish a strategic balance in the geographical distribution of the internationally owned plants and stockpiles.

The security which we see in the realization of this plan lies in the fact that it averts the danger of the surprise use of atomic weapons. The seizure by one nation of installations necessary for making atomic weapons would be not only a clear signal of warlike intent, but it would leave other nations in a position — either alone or in concert—to take counteractions. The plan, of course, has other security purposes, less tangible but none the less important. For in the very fact of cooperative effort among the nations of the world rests the hope we rightly hold for solving the problems of war itself.

It is clear that it would be unwise to undertake a plan based on the proposals which we have put forward unless there were some valid hope that they would be entered into and carried through in good faith; nevertheless, we must provide against the hazard that there may not be such faith and must ask ourselves this question: What will be the state of affairs should the plan be adopted with intention of evasion or should evasion be undertaken by any nation during the years when it is being put into effect?

The basis of our present monopoly now lies in two rather different things: knowledge, and physical facilities. The ultimate geographical balance toward which a plan for international control must work will witness the loss of both kinds of monopoly. Knowledge will become general, and facilities will neither in their legal possession nor in their geographical distribution markedly favor any one nation. Although both elements of our present hegemony will thus disappear over a period of years, quite different considerations are involved in the sharing of our knowledge and in the balancing of physical facilities.

Material Aspects of Transition

The transfer of such facilities to international control; the establishment under international control of similar facilities in other nations; the creation of stockpiles; the gradual building up of groups of men skilled in the various necessary arts—these are changes which from their very nature will require time to bring about, and which can, within not too wide limits, be scheduled and controlled. In the discussions within the United Nations Commission leading up to the adoption of the charter for the Authority, and even more in the early planning phases of the Authority's work, there will have to be some disclosure by us of theoretical information. But these discussions and these plans will not essentially alter the present superiority of the United States. They will not move its stockpiles of uranium or of fissionable material or its bombs or its operating plants, and need not alter the operation of these plants. The disclosures of information, now secret, will not create in any other nation the experience and the know-how which are so great a part of our present position of superiority.

No matter what may be the schedule of operations adopted, this situa-

tion cannot change overnight under any circumstances. Nevertheless, it is clear that very serious consideration must be given to the scheduling of those physical and legal changes which over a period of years will bring about a balanced international operation. On the one hand, the general principles underlying this scheduling will have to be the subject of negotiation, and the outcome will in one form or another have to be written into the charter. The charter may, for instance, provide that some things should not be done before a specified number of years have elapsed, or before the activities of the Authority, let us say, in the field of raw materials, have reached a certain stage of effectiveness. On the other hand, the Authority itself may by charter provision be given responsibility and discretion in the planning of its activities. It may, for instance, be called upon to certify that it is in satisfactory control of the raw materials situation before it undertakes certain of its other functions

We are aware of the great importance which attaches to a prudent and reasonable scheduling of the step by step transition from our present position. But this problem is of fundamentally different kind from those that have been discussed in this report. In this report we have attempted to discover and describe the conditions which, as we view the matter, a workable system of international control would have to satisfy.

The consideration of the steps of transition by which the special position of the United States may be relinquished involves quite other values. The sequence, the ordering, and the timing of these steps may be decisive for the acceptability of the international controls, but they will not affect its operability. Therefore, they present problems of negotiation between the nations within the UNO in the course of agreeing upon a charter for the Atomic Development Authority. Such problems of negotiation, in our opinion, are separable from the nature of the objective of the negotiation. They are problems which cannot be solved now, because they depend, among other things, on the motivation of the participating nations, on the political background of the negotiations, and on what may be conceived to be the separate, as opposed to the collective, interests of these nations.

The extent to which special precautions need to be taken to preserve present American advantages must be importantly influenced by the character of the negotiation and by the earnestness which is manifested by the several nations in an attempt to solve the common problems of international control. These questions lie in the domain of highest national policy in international relations.

We are convinced that the first major activities of the Authority must be directed to obtaining cognizance and control over the raw materials situation. This control may of course be subject to limitations, defined in the charter, on the freedom of the Authority in its early operations to alter the national distribution of raw materials. The problems of making a geological survey reliable and not prohibitively difficult are major techni-

cal problems. The raw materials control will bring the Authority face to face with the problem of access, which is both a technical and a political problem. It will bring it face to face with the need for establishing its own research agencies and for their coordination with private and national ones. These undertakings are fundamental for the operation of the Authority and to all of its future prospect of success.

There are other things which no doubt the Authority would wish to do at once. Without much delay it should set up laboratories for the study of nuclear physics and the technological problems that it must expect to encounter in its future work. It should attempt to establish suitable forms of liasion and interchange with private and national institutions working on atomic energy or on its applications or on the fundamental sciences which may be involved. In short, the Authority should get started on its research program and in establishing the patterns of its liasion with other agencies for which it will be responsible in the future.

It would be desirable that even in the earliest days the Authority act to permit the use of radioactive tracer materials and those laboratory reactors which use small amounts of denatured active material, and which seem to provide such valuable tools for research in a variety of fields.

The Authority may need to establish, even in its earliest days, planning boards to make studies of the difficult questions of stockpiling, power development, future plant construction; it may need to set up a system for the interim recording and accounting of operations in the field of raw materials, and in the production plants of the United States.

These seem to us reasonable plans for initial operations. All the other operations of the Authority are certainly subject to scheduling. They may accompany these initial operations, or they may come later. But the control of raw materials is an essential prerequisite for all further progress and it is the first job that the Authority must undertake. It will be a continuing activity, but what we are concerned with is that it should start.

In considering the special position of the United States, there are, as we have seen, the following important components, the discontinuance or transfer of which to the jurisdiction of the Authority will have to be very carefully scheduled by international negotiation: our raw material supplies; the plants at Oak Ridge and Hanford now operating to make atomic explosives; the stockpiles of bombs now in our possession; the stockpiles of undenatured fissionable materials; our atomic bomb plant and laboratory at Los Alamos. Our loss of monopoly in these elements cannot be indefinitely postponed. Some of the things we now have will have to cease; some will have to be transferred to the Authority; some will have to be paralleled by activities elsewhere.

The scheduling will determine the rapidity with which a condition of international balance will replace our present position. Once the plan is fully in operation it will afford a great measure of security against surprise attack; it will provide clear

danger signals and give us time, if we take over the available facilities, to prepare for atomic warfare. The significant fact is that at all times during the transition period at least such facilities will continue to be located within the United States. Thus should there be a breakdown in the plan at any time during the transition, we shall be in a favorable position with regard to atomic weapons.

Disclosure of Information

One of the elements in the present monopoly of the United States is knowledge. This ranges all the way from purely theoretical matters to the intimate practical details of know-how. It is generally recognized that the transmission of any part, or all, of this knowledge to another nation could provide the basis for an acceleration of a rival effort to make atomic weapons. Even that part of our knowledge which is theoretical, which can be transmitted by word of mouth, by formula, or by written note is of value in this context. If such knowledge were available to a rival undertaking it would shorten the time needed for the solution of the practical problems of making atomic weapons, be eliminating certain unworkable alternatives, by fixing more definitely design features which depend on this theoretical knowledge, and by making it possible to undertake the various steps of the program more nearly in parallel, rather than in sequence. It is not, in our opinion, possible to give a reliable estimate of how much such revalation would shorten the time needed for a successful rival effort. It is conceivable that it would not be significantly shortened. It is conceivable that it might be shortened by a year or so. For an evaluation on this point depends on information, which is not available to us, on the detailed plans and policies of such a rival undertaking, as well as on their present state of knowledge underlying it. It is, of course, clear that even with all such theoretical knowledge available, a major program, surely lasting many years, is required for the actual production of atomic weapons.

Our monopoly on knowledge cannot be, and should not be, lost at once. Here again there are limitations on the scheduling inherent in the nature of our proposals; and in the nature of the deliberations necessary for their acceptance. But even with the recognition of these limitations, there is a rather wide freedom of choice in the actual scheduling of disclosures. Here considerations of acceptability and of general political background will make a decisive contribution.

It is clear that the information, which this country alone has, can be divided more or less roughly into categories. The acceptance and operation of the plan will require divulging certain categories of this information at successive times. A schedule can outline the point at which this must occur. In particular, there is a limited category of information which should be divulged in the early meetings of the United Nations Commission discussing these problems. There is a more extensive category which must be divulged some years hence after a charter has been adopted and the Atomic Development Authority is ready to start its operations; and there are other categories that may be reserved until the Authority later un-

dertakes some of the subsequent stages of its operations, for instance, those that involve research on weapons. We are convinced that under the plan proposed in this report such scheduling is possible, though it is clear, as we have pointed out, that many factors beyond the scope of this report, and involving the highest considerations of international policy, will be involved in such schedules. We wish to emphasize that it will involve an initial divulging of information, which is justifiable in view of the importance of early progress on the path of international cooperation.

It is true, as the Secretary of State has said, that there is nothing in the Resolution setting up the Atomic Energy Commission, that compels the United States to produce information for use of the United Nations Commission. But the point that needs to be emphasized is that unless we are prepared to provide the information essential to an *understanding* of the problem, the Commission itself cannot even begin the task that has been assigned to it.

Let us examine in a little more detail the nature of the information which is required in the early stages. What is important for the discussions in the United Nations Organization Commission is that the Members and their technical advisors, have an understanding of the problem of the international control of atomic energy and of the elements of the proposals that United States member will put forward. They must be in a position to understand what the prospects for constructive applications of atomic energy are and to appreciate the nature of the safeguards which the plan we here propose affords. They must be in a position to evaluate alternatives which may arise, and to have insight into the rather complex interrelations of the various activities in this field. Above all they must have a sound enough overall knowledge of the field as a whole to recognize that no relevant or significant matters have been withheld. For the process of reaching common agreement on measures of international control presupposes an adequate community knowledge of fact. Much of the information which is required for this purpose is already widely known. We are convinced, however, that there are further items now held by us as secret without which the necessary insight will be difficult to obtain. These items are of a theoretical and descriptive nature and have in large part to do with the constructive applications of atomic energy. In our opinion, they are largely qualitative; and they involve almost nothing of know-how.

On the other hand, when the Atomic Development Authority is in existence and undertakes operations in a given field, it must have made available to it all information bearing on that field—practical as well as theoretical. Thus if the Authority, as its first major undertaking, attempts to obtain control of raw materials, we must be prepared to make available to it *all* knowledge bearing on this problem. This will, of course, be a common obligation on all participating nations. Conversely, should it by charter agreement be determined that research and development in the field of atomic explosives will be undertaken by the Authority only at a late date, the

specific technological information relating to such developments would not be required by it in the earlier phases. It is important to bear in mind that before the Authority can undertake some of its functions, such as the construction of reactors or the development of power, it will have to spend some time in planning these activities and in research directed toward them, and that information must be made available early enough to make such planning and research effective.

These are examples of requirements for information by the Atomic Development Authority at certain stages of its progress. In accepting the plan here recommended for international control, the United States will be committed to making available this information at the time, and in the full measure required by the operating necessities. Once the sequence and timing of stages has been fixed by negotiation and agreement between the nations, a minimum rate of disclosure of information will have been fixed by the agreement as well. A too cautious release of information to the Atomic Development Authority might in fact have the effect of preventing it from ever coming to life. For one of the decisive responsibilities of the Authority is the establishment and maintenance of the security of the world against atomic warfare. It must be encouraged to exercise that responsibility, and to obtain for itself the technical mastery that is essential.

We may further clarify the nature of the disclosures required by this board's proposals by a reference to a report. We have had the opportunity to examine in detail a report of December, 1945, prepared for the Manhattan District by its Committee on Declassification, a committee of seven scientists, including the wartime heads of all the major laboratories of the Project.[1] This Committee was directed to report on a policy of declassification—that is disclosure—of scientific and technical material now classified as Secret, a policy *which would best promote the national welfare, and protect the national security*. In interpreting its directive the Committee limited itself to a consideration of these objectives *in the absence of any system of international control*. It recommended against declassification at the present time of a very considerable body of technical, technological, industrial, and ordnance information, that is information bearing directly on the manufacture of weapons and the design and operation of production plants. But it recommended the prompt declassification of a large body of scientific fact and of technical information of non-critical nature and wide applicability. It expressed the view that the further declassification of critical items of basic theoretical knowledge would conduce, not only to the national welfare, but to the long-term national security as well—no doubt because of the damaging effect which continued secrecy in these matters could have on our own scientific and technical progress. Corresponding to these distinctions, the Committee divided our secret scien-

[1]Membership of this Committee included R. F. Bacher, A. H. Compton, E. O. Lawrence, J. R. Oppenheimer, F. G. Spedding, H. C. Urey, and R. C. Tolman, Chairman.

tific and technical information into three categories, the first of which it recommended for immediate declassification; the second of which it recommended for eventual declassification in the interests of long-term national security of the United States; and for the third of which it recommended against declassification in the absence of effective international control. We have tried to see what technical information this board would find essential for the sort of understanding that must be established as a basis for discussion in the UNO Commission, and to compare this with the items listed in the report of the Committee on Declassification. Many of the facts needed are already public; many are included in Class One; the remainder are all in Class Two, and comprise perhaps one-third of the items there listed. It is important again to emphasize that the Declassification Committee's recommendation was aimed at furthering our own long-term national security in the absence of international measures.

We wish to emphasize that the initial disclosures will place in the hands of a nation (should it be acting in bad faith) information which could lead to an acceleration of an atomic armament program. We do not regard this circumstance as in any way peculiar to the plan recommended in this report. It is inherent in the concept of international control. The adoption of any workable scheme of international control may shorten the time during which the United States has a position as favorable as it has today. We cannot be sure of this, but we must be prepared for it.

In this section we have been discussing the problem of transition to international control as it affects the security of the United States. During this transition the United States' present position of monopoly may be lost somewhat more rapidly than would be the case without international action. But without such action the monopoly would in time disappear in any event. Should the worst happen and, during the transition period, the entire effort collapse, the United States will at all times be in a favorable position with regard to atomic weapons. This favorable position will depend upon material things; less and less will it rest upon keeping nations and individuals ignorant.

When fully in operation the plan herein proposed can provide a great measure of security against surprise attack. It can do much more than that. It can create deterrents to the initiation of schemes of aggression, and it can establish patterns of cooperation among nations, the extension of which may even contribute to the solution of the problem of war itself. When the plan is in full operation there will no longer be secrets about atomic energy. We believe that this is the firmest basis of security; for in the long term there can be no international control and no international cooperation which does not presuppose an international community of knowledge.

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